

The Direction of Virtual Vehicle Simulations for Military Training

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May 2006

SUMMARY

A Live, realistic environment has always been the preferred medium for military training. However, numerous considerations such as safety and constrained resources; along with technical advances, continue to make virtual and constructive simulations attractive as supplements to live training – so long as these alternatives can offer resource-saving benefits. In fact, virtual simulations are currently capable of supporting many individual and an increasing number of collective tasks required for training our armed forces. However, there are significant limitations that reduce the effectiveness of virtual training simulations, and stand as roadblocks to a seamless objective LVC capability. Most virtual simulations focus on training an individual Warfighter on one specific battlefield operating system. They do not enable small unit leaders and commanders to effectively manage the integration of that system into a combined arms fight. While standards of interoperability exist, networking these separate virtual devices together to enable combined arms team training requires a platoon of civilian technicians and weeks of modification. Geographically distributed events present major hurdles. The specificity of virtual terrain databases which are based on the individual requirements of their system, preclude a fair-fight with other databases of the same geographic terrain. Some of these limitations are technical in nature and will be addressed through advances and focused research in the field of virtual simulation. Others are based on current technical architectures, stove-piped requirements, and the lack of common synthetic environment products. This paper examines current capabilities and suggests requirements necessary for future virtual simulations to enable the LVC vision. We may not achieve a “Star Trek Holodeck” – like training capability for some time. However, future efforts must focus on making the virtual training experience more “life-like” to the individual and collective audiences that commanders are required to train. Future enhancements to combined arms virtual simulations will help lessen the impact of limited resources, and will help ensure a continued training edge for the core fighting force of the transformed U.S. Army, the Brigade Combat Team. –DWR.

The Armed Forces of the United States of America maintain an emphasis on preparedness through focused, repetitive training. As we look forward, the challenge is to maintain, and even improve upon this training “edge”. A live-training, realistic environment has always been the preferred medium for military training. However, numerous considerations such as safety and constrained resources; along with technical advances,

Riggins, D.W. (2006) The Direction of Virtual Vehicle Simulations for Military Training. In *Virtual Media for Military Applications* (pp. 13-1 – 13-6). Meeting Proceedings RTO-MP-HFM-136, Paper 13. Neuilly-sur-Seine, France: RTO. Available from:
<http://www.rto.nato.int/abstracts.asp>.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 01 JUN 2006		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The Direction of Virtual Vehicle Simulations for Military Training				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) United States Army Program Executive Office for Simulation, Training and Instrumentation ATTN: Project Manager for Combined Arms Tactical Trainers 12350 Research Parkway Orlando, FL 32828 USA				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM002024., The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 14	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

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continue to make virtual and constructive simulations attractive as supplements to live training – so long as these alternatives can offer resource-saving benefits. In fact, virtual simulations are currently capable of supporting many individual and an increasing number of collective tasks required for training our armed forces. The planned implementation of the Army's Future Combat System has the enormous task of providing a significantly enhanced, integrated Live, Virtual and Constructive (LVC) training capability.

There are significant limitations that reduce the effectiveness of virtual training simulations, and stand as roadblocks to a seamless objective LVC capability. Most virtual simulations focus on training an individual Warfighter on one specific battlefield operating system. Yet, they do not enable small unit leaders and commanders to effectively manage the integration of that system into a combined arms fight. While standards of interoperability exist, networking these separate virtual devices together to enable combined arms team training requires a platoon of civilian technicians and weeks of modification. Geographically distributed events present major hurdles. The specificity of virtual terrain databases that are based on the individual requirements of their system, preclude a fair-fight with other databases of the same geographic terrain. Training for the conduct of mounted vehicular operations cannot be readily modified to permit dismounted operations. The list goes on.

The purpose of this paper is to examine the strengths and weaknesses of current virtual training devices. We will also explore the factors that influence development and improvements in training systems. By identifying positive aspects of our current systems, and examining possible capabilities and factors shaping future systems, we can hopefully gain insight into the art of the possible for virtual training that is realistic, multi-echelon, and that facilitates high fidelity mission rehearsal.

Status of current and near-term virtual training systems

The current state-of-the-art for virtual systems in the area of ground and air vehicular training offers many advantages over similar systems from the past. Technologically speaking, virtual devices rely almost exclusively on computing power to replicate operational conditions in the simulated scenario. I discuss the effects and direction of technology on virtual simulations later in this paper. However, the capability and cost of today's personal computers and commercial video cards provide very capable, low-cost computational power for our training devices, and they do so at a relatively small size and weight. This reduced cost and footprint for computational power continues to be a key enabler for increased mobility and deployability, along with tactile and spatial fidelity of the current generation of virtual devices.

Strength – Increased Mobility

The "ilities" – supportability, maintainability, sustainability, affordability; the list goes on. We use these terms to describe the logistical effectiveness of a training system. More than ever before, today's training devices must be mobile and deployable in order to be effective. US Army modularity, BRAC (Base Realignment And Closure), ARFORGEN (Army Force Generation Model), combat operations in Afghanistan and Iraq, and constrained Defense Budgets are just some of the factors that require virtual training solutions capable of being provided at the necessary time and place, without major transportation and technically demanding support requirements. These same factors also require training solutions that are available to support home station virtual training as well as training support to Combat Training Centers (CTCs). In the past, each installation would be fielded with its own family of virtual training systems. Now, mobile training systems allow fewer devices to be positioned where they are needed to support training. This increases utilization for the devices and reduces the logistical burden associated with maintaining additional devices.

Strength – Tactile and Spatial Fidelity

Current virtual training systems offer an unprecedented level of fidelity, in terms of look and layout (spatial fidelity), as well feel and control function (tactile fidelity). In many cases, actual components from combat vehicles or aircraft are utilized in the training device to give the trainee the feeling of really being there. Control loading systems provide incredibly realistic force feedback on steering, power and braking controls. Again, very capable computer systems running highly accurate models drive the control loading systems and other motion queuing systems on today's simulators. Six degree-of-freedom full motion systems complete the proprioceptive stimuli that cause the trainee to believe he or she is actually moving and operating their vehicle. If the objective of the simulation is to train a novice in the safe and efficient operation of the device with minimum time and resources spent operating the actual device, today's simulations come closer than ever.

So what are the shortcomings of current systems and where do these systems need to improve in light of future requirements?

Trainer Concurrency

One of the most pervasive problems with virtual training systems is ensuring that the trainer accurately represents its weapon system. Budgetary and other constraints are causing many systems to be utilized for tens of years beyond their originally planned useful life. Rather than retiring the system and replacing it with a totally new developmental effort, upgrades and product improvements are implemented to enable the system to operate in the contemporary operational environment. These modifications include everything from engines and power-trains to radios and defensive countermeasures. Once the modifications and upgrades are implemented in the fielded system, the trainer is no longer concurrent and a cost-benefit analysis must be conducted to determine if the trainer should be modified. Using the examples above, most operator trainers would require a software model change to accurately represent vehicle behavior with the new engine. Radio modifications and the introduction of countermeasures will likely require software modeling changes and a hardware change to the configuration. The higher the fidelity of the training device is, the greater the need for concurrency. If upgrades to the trainer are considered as part of the total system upgrade, concurrency problems can be minimized. However, more often than not, trainer concurrency is not considered until soldiers receive the new weapon system and complain about differences with the trainer.

Instructor / Operator Function and Support

One of the main responsibilities of any military commander is to train his organization. For individual and small unit collective training, he typically appoints members of the command who are responsible for the planning, coordination, and execution of this training. Virtual training devices are key enablers in helping the commander meet this requirement, however many of today's virtual training systems impose a heavy penalty on the commander by being overly complex to operate and maintain. As a result, he must either commit soldiers from his command to focus on operation and maintenance of the device, or he must allocate some of his limited operational training funds to hire contractors to perform this function. There is not currently an attractive option available, and training systems of the future must be designed and built with this in mind.

Terrain Databases and Models

Terrain Databases, visual models and supporting physics models form the synthetic natural environment, or "out-the-window" world in which virtual simulators operate. Few aspects of virtual training systems affect

realism within the trainer the way that these elements do. Arguably, no other aspect of virtual simulations affects the immersive aspect of the training experience as much as visual terrain and models. But in order for the experience to be truly immersive, the “out-the-window” view is only one aspect of the terrain database that has to be accurate. Views for night vision, targeting systems, radio propagation, semi-automated forces, and other aspects of the database must also be precisely modeled and each of these database views must be correlated to ensure continuity for the trainee. Optimizing visual terrain and models for an individual trainer is becoming easier as time goes by. However, new development of a large area, geographically specific visual terrain database takes the better part of a year – far too long to be tactically relevant. Further, costs for these large terrain databases is often in excess of \$1 Million USD – far too expensive.

Since training systems should allow commanders to train their units as they will fight in combat, visual terrain databases and models should facilitate networking of other training devices for unit level collective training scenarios. Complicating the issue, however, is the fact that these different training simulations are developed and built around inconsistent architectures. Various image generator (IG) technologies are employed and each has a different formatting requirement. Computational functions are inconsistently assigned to IG computers or host computers from system to system. Different physical and visual models are incorporated and their mapping or computational description varies from system to system. All of these factors combine to create an interoperability nightmare for commanders where achieving fair-fight interoperability in a large, virtual, collective exercise requires an army of technicians and months of pre-exercise system modifications. There are solutions emerging to help address these issues such as the U.S. Army’s Synthetic Environment Core project, but implementation will take several years and is currently not mandated across the virtual domain for government or industry.

Deployability and Logistical Burden

Given the current world-wide security environment and on-going deployments for the U.S. Army in the Global War on Terrorism, there is an unprecedented demand for virtual training devices in the forward deployed areas of operation. This environment is often very unfriendly to the high-tech components of our virtual training systems. The effects of very fine particles of sand, often blowing sand, combined with dirt from field uniforms and boots, and limited time for cleaning can be catastrophic. Virtual training systems must be designed with these environments in mind. Ruggedized components, interior over-pressure, sealed doors, and other similar considerations can be the difference in keeping the systems operational. Ease of maintenance and normal operations is also critical in an austere environment.

Linking L-V-C and ability to support BDE & higher battlestaff training

The topic of interoperability was discussed earlier in the paper. This discussion involved the need for tools to enable horizontal interoperability of different combined arms virtual training devices for individuals and small units. However, in order for these virtual training devices to enable commanders of battalions and brigade combat teams to train their soldiers and their battle staffs, vertical interoperability, or multi-echelon training capability is also required. As stated initially, live training is the preferred domain for most tasks since it offers the highest degree of realism. However, virtual systems can supplement live training and constructive systems can play a key role in providing the large-scale forces necessary to train higher echelon battle staffs and commanders. What’s currently missing is the ability to link these domains together for multi-echelon training that begins with the individual soldier and includes Division and Corps level battle staffs and commanders in a fair-fight, interoperable Live-Virtual-Constructive exercise. Like visual terrain data and models, the U.S. Army has a new effort underway to create a Live, Virtual, Constructive Integrated Architecture. This effort will require virtual training device developers to re-think the way that these systems

replicate and operate with live systems. Constructive simulation developers must also work to incorporate an ability to operate with live soldiers as well as live and virtual systems. Breaking down the barriers between live, virtual, and constructive training along with the other improvements discussed earlier will enable commanders to conduct mission rehearsal at the time and location of their choosing.

Mission Rehearsal – The Gold Standard

If the future requirements for virtual simulation devices could be summarized into one capability, it would be the capability for commanders to conduct multi-echelon mission rehearsal. There are many developers who claim to offer the ability to conduct mission rehearsal in the virtual domain. However, field commanders and small unit leaders alike continue to state the ability to conduct mission rehearsal as their highest training system priority. In this context, mission rehearsal involves creating the sights, sounds, feelings, smells and even tastes of the actual battlefield. Commanders, battle staffs, small-unit leaders and individual soldiers must all have their senses stimulated to believe in the realism of the training event. The task and purpose associated with the mission must be able to be played out in real time, with realistic and uncertain enemy actions, reactions, and counteractions. Friendly troops and all of the capabilities that can be employed in the actual execution of the mission must be incorporated. Terrain must be accurate and dynamic so that tactical maps can be employed, and so that environmental and weapons physical effects can be allowed to fully affect the outcome of each employment. In urban settings, buildings must be accurately represented both outside and inside. Ballistic effects of weapons must be portrayed realistically down to the penetrability of specific types of walls and doors by specific weapons types. After action reviews must be comprehensive and must allow leaders to capture and explore the rationale for decisions made in the heat of battle. Further, decisions implemented by friendly or enemy semi-automated forces (SAF) must also be explained and must be reactive enough to portray the intelligent, learning enemy that we face on today's battlefields. Vehicle behaviors and capabilities must be accurately portrayed. Friendly force casualties must occur accurately and must be as obvious as a casualty in live action. High fidelity medical virtual simulations must be incorporated to exercise the casualty handling and treating aspect of operations. "Fog of war" factors such as unreliable communications, weapons malfunctions, map errors, and unexpected weather conditions must create the same amount of uncertainty in the simulation. In short, soldiers, leaders, staffs, and commanders should all leave the training event feeling as though they have been in combat.

Change Agents for better future virtual simulations

There are several emerging factors creating synergy for the improvement of virtual training devices. One of the most influential factors for the U.S. Army is the ongoing transformation to a more modular force with focus on fielding, manning and equipping Brigade Combat Teams (BCTs). In short, this initiative creates a more uniform set of building block, functionally focused BCTs that can be teamed together to conduct operations. BCTs from Active, Reserve and National Guard components that have never previously operated together and that are based at geographically dispersed locations may be teamed together. Time and live training range size and availability are always constrained resources, so opportunities to bring these BCTs and their command and control headquarters together for iterative training will be limited. This scenario creates an unprecedented need for a robust distributed live, virtual and constructive training capability that encompasses individual, team, and collective, multi-echelon battle staff training.

In addition to Army transformation, the other U.S. military branches are also undergoing transformation, as is the joint nature of today's operations. U.S. military operations are inherently joint in nature and will only become more so in the future. These operations are also combined in nature, involving a variety of forces and capabilities from coalition allies. In order to adequately account for these unmistakable trends, virtual training

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capabilities for all of these forces must be capable of joint and coalition scalability to incorporate the ability to train as we fight and to enable the best possible training for all forces, staffs and commanders who will be involved in the operation.

Throughout the paper we have alluded to the impact of technology on the world of virtual training devices. The U.S. Army's Future Combat System program is focused on harnessing emerging technologies and providing them to soldiers and commanders for operations and training. In that vein, numerous emerging technological advances will continue to make improved virtual simulations possible. Processing capability will continue to improve. Improvements in the area of visualization will enable more realistic virtual training scenarios. Enhanced models of vehicles, systems, terrain, weather and buildings will enable training events to become better predictors of operational outcomes. All of these factors offer great promise, but technology must also be employed to make these devices more affordable since budgetary constraints will always be limiting factors. Technology must also be focused on enabling training for geographically dispersed trainees. Finally, technology must be harnessed to make our virtual training devices more intuitive to operate. One promising area of technology that may greatly impact these metrics is the area of commercial gaming.

Over the last several years, there has been an explosion in the number and scope of on-line commercial games. So called "first person shooter" games enable anyone with a personal computer or commercial game console to be immersed in increasingly realistic military scenarios. Through the Internet and voice over Internet protocol, gamers can communicate with and team with or oppose other gamers from around the globe whom they have never met. Many games offer intuitive scenario development tools and scalable models that enable the gamer to also be a training scenario author. Each year, game vendors continue to enhance these capabilities.

While the potential offered by gaming is unmistakable, I am not suggesting that game-based training technologies should, or can currently replace virtual simulations for military training. Today's commercial games fall short in many of the areas necessary to assume this role such as fidelity, procedural accuracy, and security. However, based on all of the trends stated above, I am suggesting that commercial gaming and game engines should be thoroughly explored for their potential ability to supplement and enhance virtual training, and to make it more affordable, easier to operate, easier to upgrade, and easier to train geographically dispersed trainees.

Conclusions

The objective of this paper was to examine requirements for future virtual simulations with emphasis on vehicle training devices. Interestingly, the requirements for future devices are remarkably similar to those for current virtual trainers, so the future requirements were presented from the context of current limitations. Some of these limitations are technical in nature and will be addressed through advances and focused research in the field of virtual simulation. Others are based on current technical architectures, stove-piped requirements, and the lack of common synthetic environment products. We may not achieve a "Star Trek Holodeck" – like training capability for some time. However, future efforts must focus on making the virtual training experience more "life-like" to the individual and collective audiences that commanders are required to train. They must enable multi-echelon mission rehearsal across live, virtual and constructive domains. Future enhancements to combined arms virtual simulations must also help lessen the impact of limited resources, and help ensure a continued training edge for the core fighting force of the transformed U.S. Army, the Brigade Combat Team.



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Virtual Media for Military Applications

June 13 – 15, 2006



Agenda

- Current Considerations
- Virtual System Strengths
- Areas for Improvement
- Mission Rehearsal
- Conclusions



Current U.S. Army Considerations



- An Army at War
- An Army Undergoing Transformation
 - Expeditionary Capability
 - More Uniform/Modular Composition
 - Brigade Combat Team “building blocks”
- Training Capabilities Must Also Transform
- DTLOMPF
 - Doctrine, **Training**, **Leader Development**, Operations, **Materiel**, Personnel, Facilities



Current Strengths



- Mobility
 - Many systems are transportable
 - Permit “Combat Training Center” quality at home-station
- Tactile Fidelity
 - Increase use of actual vehicle/weapon components
 - Control loading solutions provide realistic feedback
- Spatial Fidelity
 - Computer Aided Virtual Engineering (CAVE) facilitates accurate cab/cockpit portrayal
 - Use of actual vehicle components



Areas for Improvement

- Concurrency
- Instructor/Operator Function & Support
- Terrain Databases & Models
- Deployability & Related Logistical Burden
- Linkage to the Larger Collective “Fight”
 - Live & Constructive
 - Multi-echelon (BDE & Higher Staff)
 - Distributed, large unit exercises





Target: Mission Rehearsal

- What it is (a partial list)
 - Terrain, time, weather, C2, etc. specific
 - MOUT / building specific
 - Enemy specific with appropriate action & counteraction
 - Individual & collective task inclusive
- What it is not (also a partial list)
 - A “stand-alone” vehicle or training device
 - Separated from individual & crew tasks
 - A closed system with scripted threat



Conclusions



- Focus Future Efforts on BCT
 - Individual vehicle trainers must “feed” higher level collective and staff training events
- Decreased footprint, logistical support & cost
- Increased concurrency and live/constructive linkage
- Strive for multi-echelon Mission Rehearsal